Strain Effects in $Nd_{0.5}Sr_{0.5}MnO_3$ Films

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CE-type ordering of the charge, orbital, and magnetic structures (see Figure 1) is the low temperature phase of most half-doped perovskite manganites. In the $Nd_{1-x}Sr_xMnO_3$ system, CE-type ordering exists in a very narrow doping range around x=0.5,[1] and therefore small changes in weight among the various degrees of freedom can have large effects on the ground state low temperature phase. Substrate-induced strain can be used in films to affect this balance between the degrees of freedom, and the amount of strain can be tuned through the use of annealing. In this abstract, x-ray diffraction studies of strain effects on the low temperature phases of two $Nd_{0.5}Sr_{0.5}MnO_3$ films are reported.

The ~2000 Å thick $Nd_{0.5}Sr_{0.5}MnO_3$ films were grown on $LaAlO_3$ substrates, using the pulsed laser deposition technique. The resistivity of the as-grown and annealed (at 850 C for 10 hours) films were measured as a function of temperature, and both films were observed to go through a metal-insulator transition near 250 K. At lower temperatures, the resistivity of the as-grown film increased gradually below ~100 K, while the annealed film remained metallic down to the lowest temperature at which its resistivity was measured (4 K).

The different low temperature transport behaviors of the two films suggest that only the as-grown film becomes charge-ordered—in perhaps the CE-type structure. X-ray diffraction measurements were therefore carried out in order to investigate this hypothesis. Both films were found to consist of essentially two components, with different degrees of strain. From comparisons to studies of thinner films,[2] the more highly-strained component in each film can be associated with an insulating interfacial phase, which suggests that the more bulk-like component is responsible for the metallic behavior at intermediate (100-250 K, as-grown film) and low (< 250 K, annealed film) temperatures. Associated with the bulk-like component in each film were superlattice peaks, and the intensities of these peaks were measured as a function of temperature. The peak intensities were observed to behave similarly in the two films—decreasing gradually with increasing temperature. Data from measurements of the annealed sample are shown below in Figure 2.

The x-ray diffraction results indicate that both films go through a broad transition, resulting in the presence of superlattice peaks. While this transition is suggestive of charge ordering, such a conclusion is inconsistent with the metallic transport behavior observed in both films. A more likely explanation for the observation of the superlattice peaks is a strain-induced change in symmetry, from *Imma*—the crystal structure of bulk $Nd_{0.5}Sr_{0.5}MnO_3$—to a structure with lower symmetry.

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References: [1]R. Kajimoto, H. Yoshizawa, H. Kawano, H. Kuwahara, Y. Tokura, K. Ohoyama, and M. Ohashi, Phys. Rev. B **60**, 9506 (1999). [2]W. Prellier, A. Biswas, M. Rajeswari, T. Venkatesan, and R.L. Greene, Appl. Phys. Lett. **75**, 397 (1999).

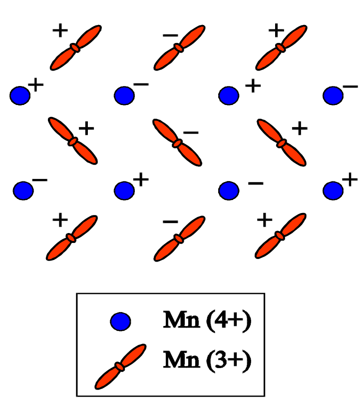

Figure 1. 2D schematic of CE-type charge, orbital, and magnetic structures. The + and – signs refer to the magnetic structure.

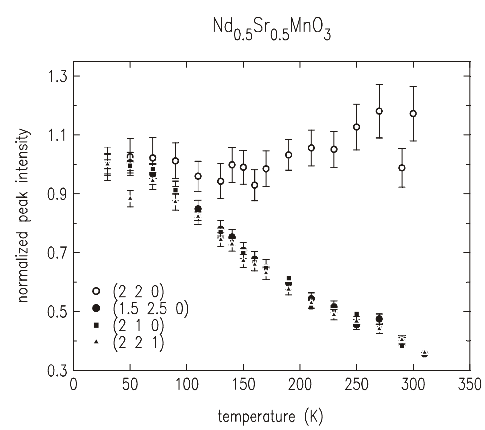

Figure 2. Peak intensities of (220) Bragg peak (o) and (1.5 2.5 0) (●), (210) (■), and (221) (▲) superlattice peaks, normalized to values at 30 K. Data are from measurements of annealed sample.